

# DETERMINATION OF A FATIGUE ENDURANCE LIMIT FOR AIRFIELD FLEXIBLE PAVEMENTS USING CC1 FULL SCALE TESTING DATA AT THE NATIONAL AIRPORT PAVEMENT TEST FACILITY



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# Acknowledgment

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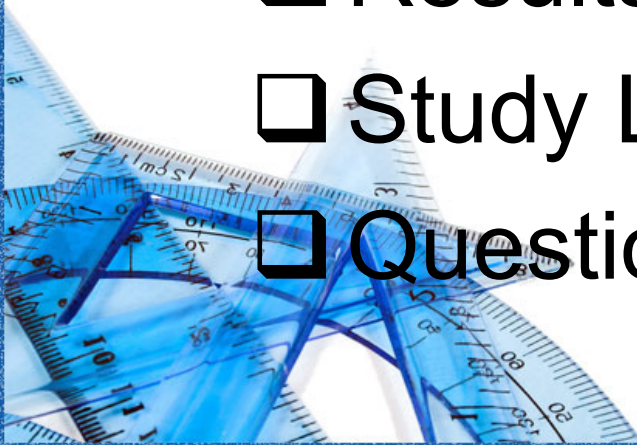
The authors would like to acknowledge the Federal Aviation Administration for funding this study.



# Presentation Outline

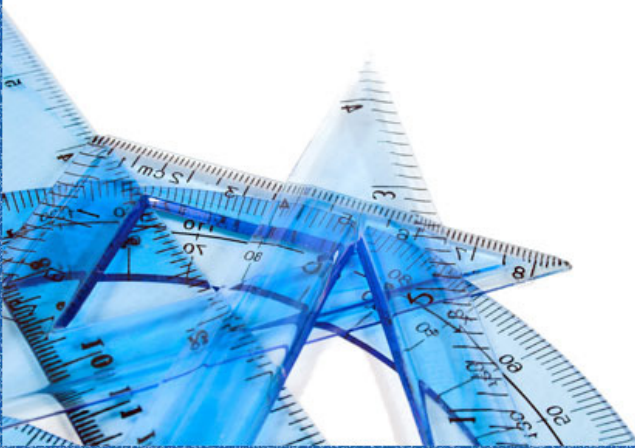
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- ☐ Background & Problem Statement
- ☐ Study Objective
- ☐ Research Approach
- ☐ Facility Layout
- ☐ Results & Findings
- ☐ Study Limitations
- ☐ Questions

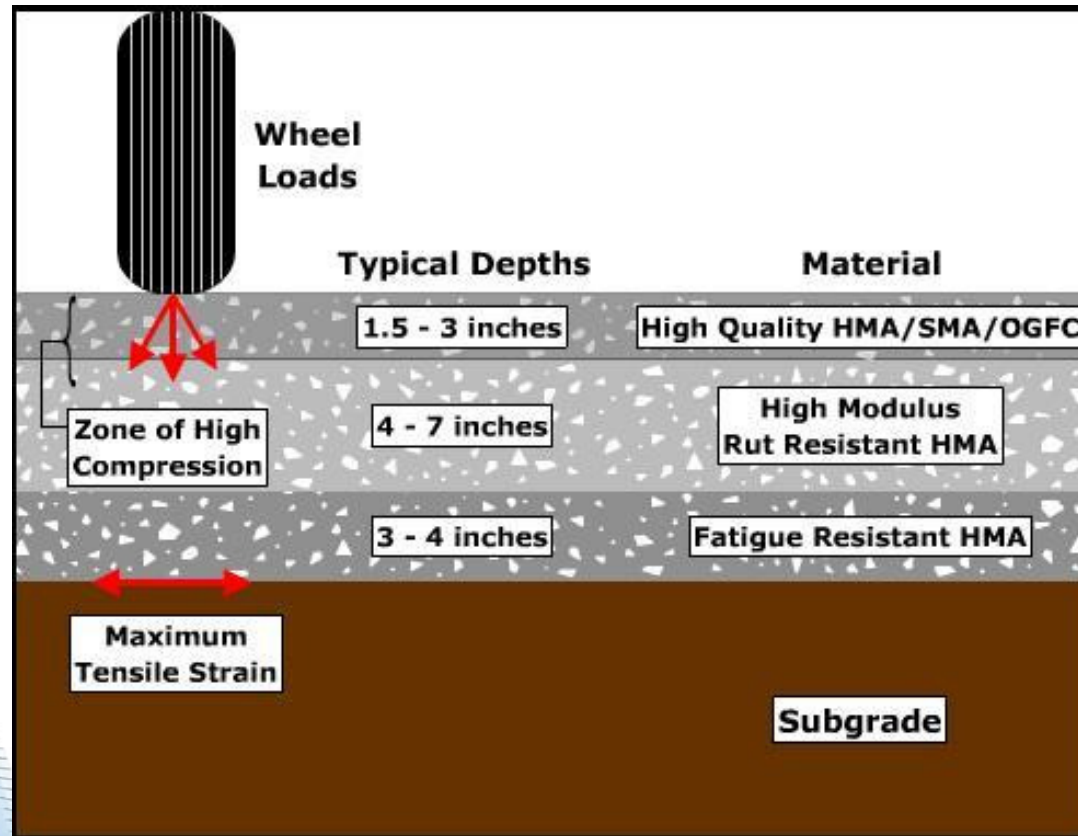




# Background & Problem Statement



# Perpetual Pavements



Typical Perpetual Pavement Design  
([pavementinteractive.com](http://pavementinteractive.com))

# Literature Summary

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Authors	Research
<b>Ghuzlan, K.A., and Carpenter, S.H. (2000).</b>	Developed a dissipated energy model to predict fatigue endurance limit for highway pavements.
<b>Carpenter, S.H., Ghuzlan, K.A., and Shen, S. (2003)</b>	Suggested using 70 microstrain as a fatigue endurance limit for highway pavements.
<b>Shen, S. and Carpenter, S H (2007)</b>	<p>Refined the dissipated energy fatigue endurance model. The new model was found to be dependent on mixture constituents, loading type, and testing conditions.</p> <p>Experimental data suggested that the fatigue endurance limits of highway pavements predicted using the refined model ranges from 70 to 350 microstrain.</p> <p>Healing is depending on the rest period between loading cycles.</p>

# Problem Statement

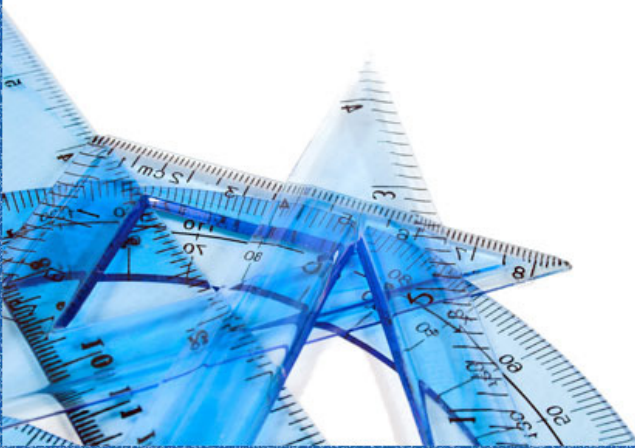
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- ❑ Limited to no research was conducted for using field data to estimate airfield pavement's fatigue endurance limit.
- ❑ Therefore, there is a need to develop a methodology for estimating pavement fatigue endurance limit using field testing results.





# Study Objective

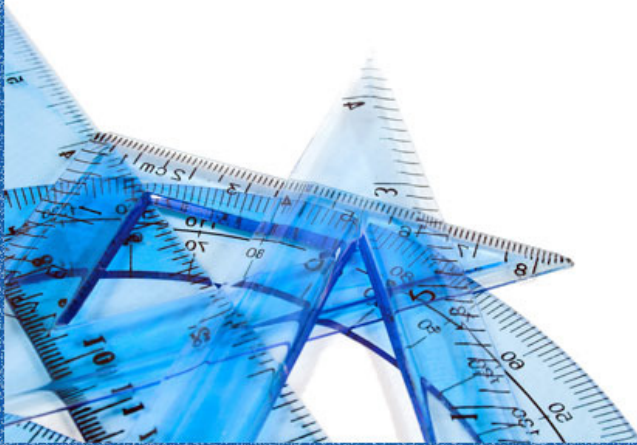




# Study Objective

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- ❑ Estimate a strain-based fatigue endurance limit for the airfield flexible pavements placed during Construction Cycle One (CC1) tensile strain data.



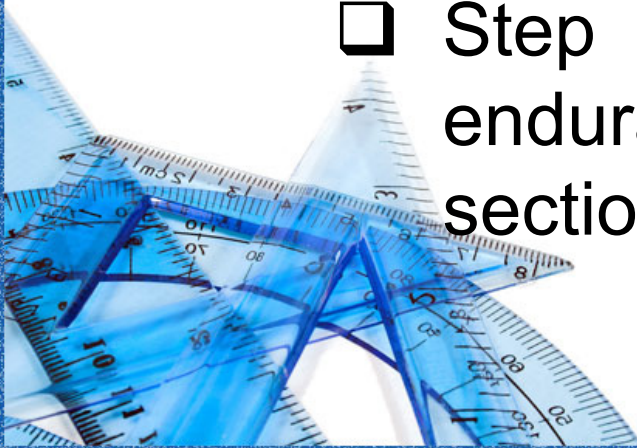
# Research Approach



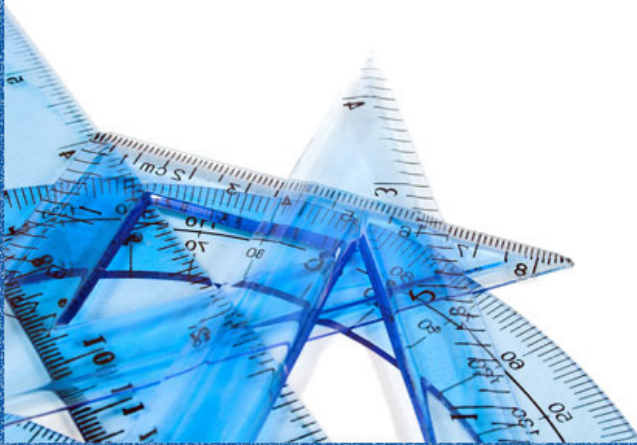
# Research Approach

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- ❑ The following steps were necessary to accomplish the study objective:
  - ❑ Step 1: obtain tensile strain data from FAA website;
  - ❑ Step 2: filter strain data to good and bad; and,
  - ❑ Step 3: estimate strain-based fatigue endurance limit for each pavement section.



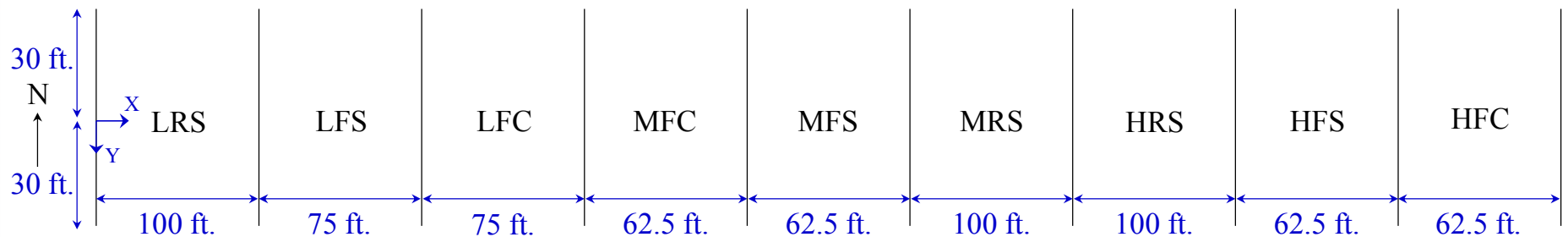
# Facility Layout (CC1)



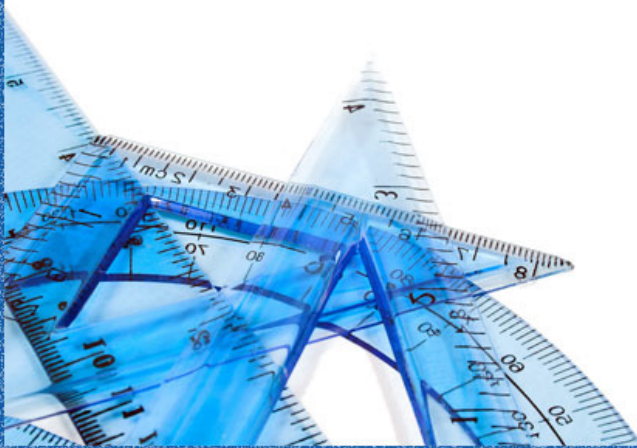


# Facility Layout (CC1)

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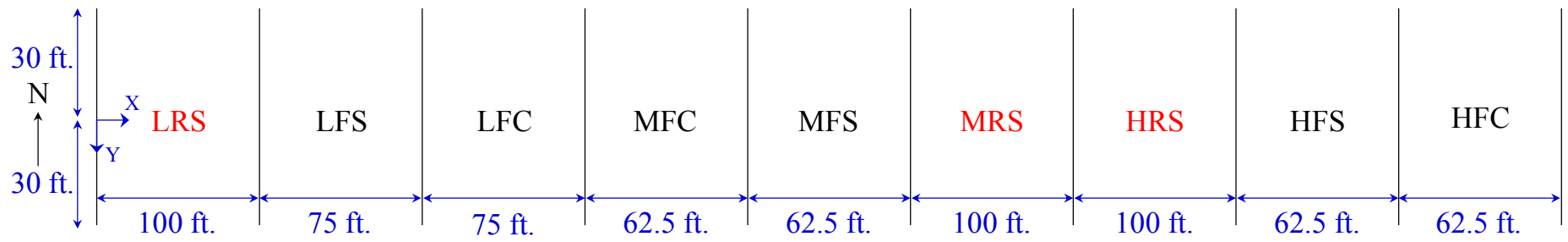


Nine Pavement Sections: Three Rigid and Six Flexible

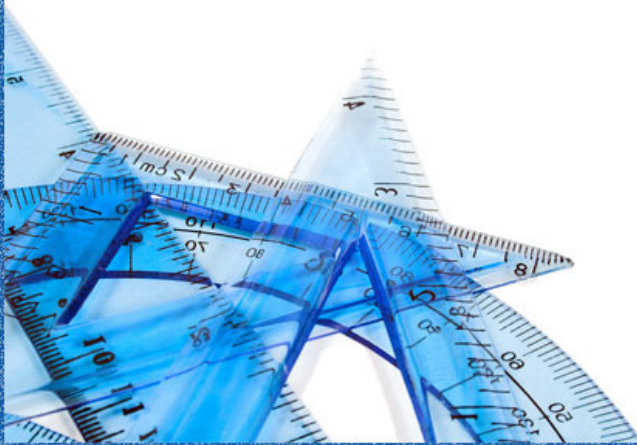


# Facility Layout (CC1)

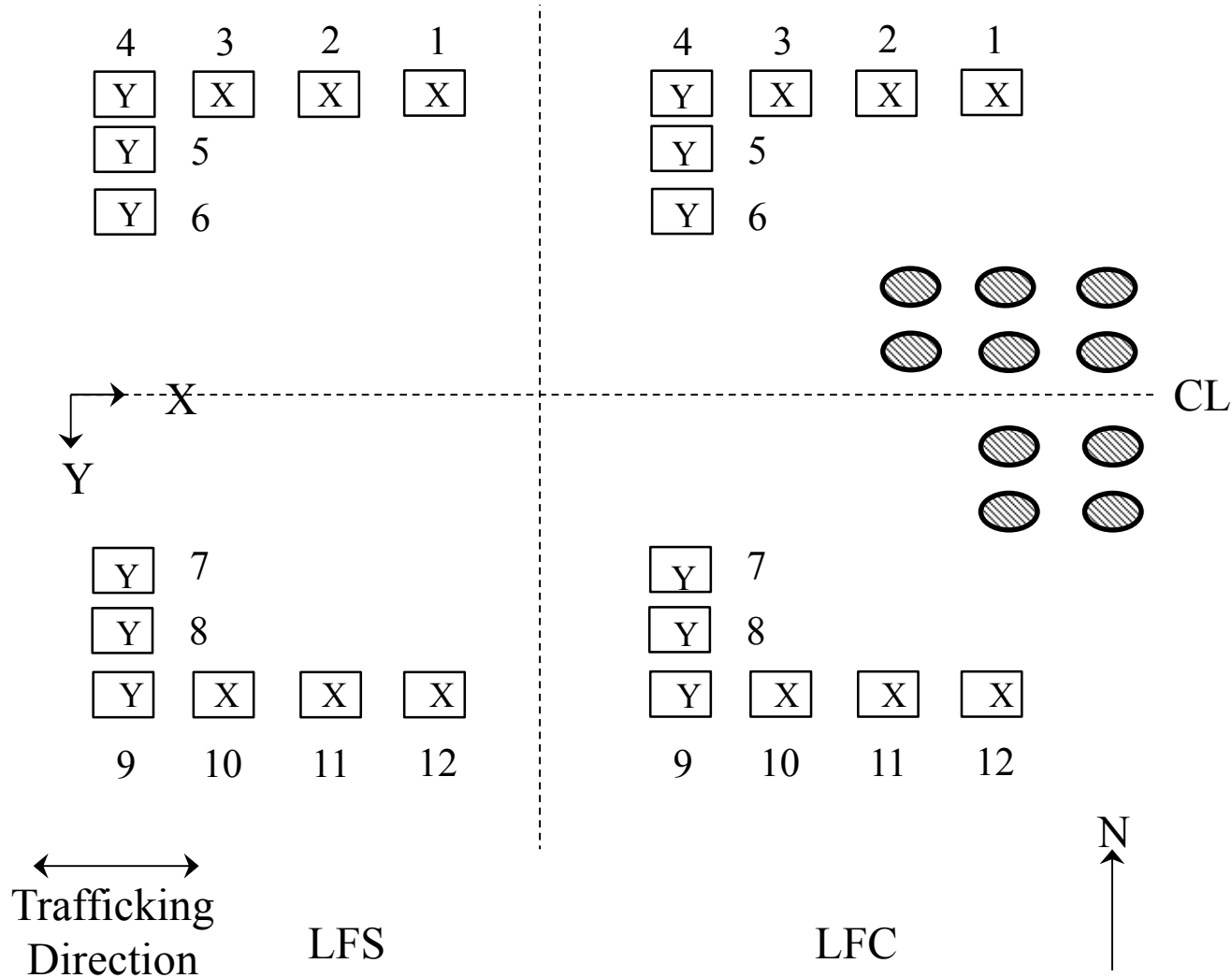
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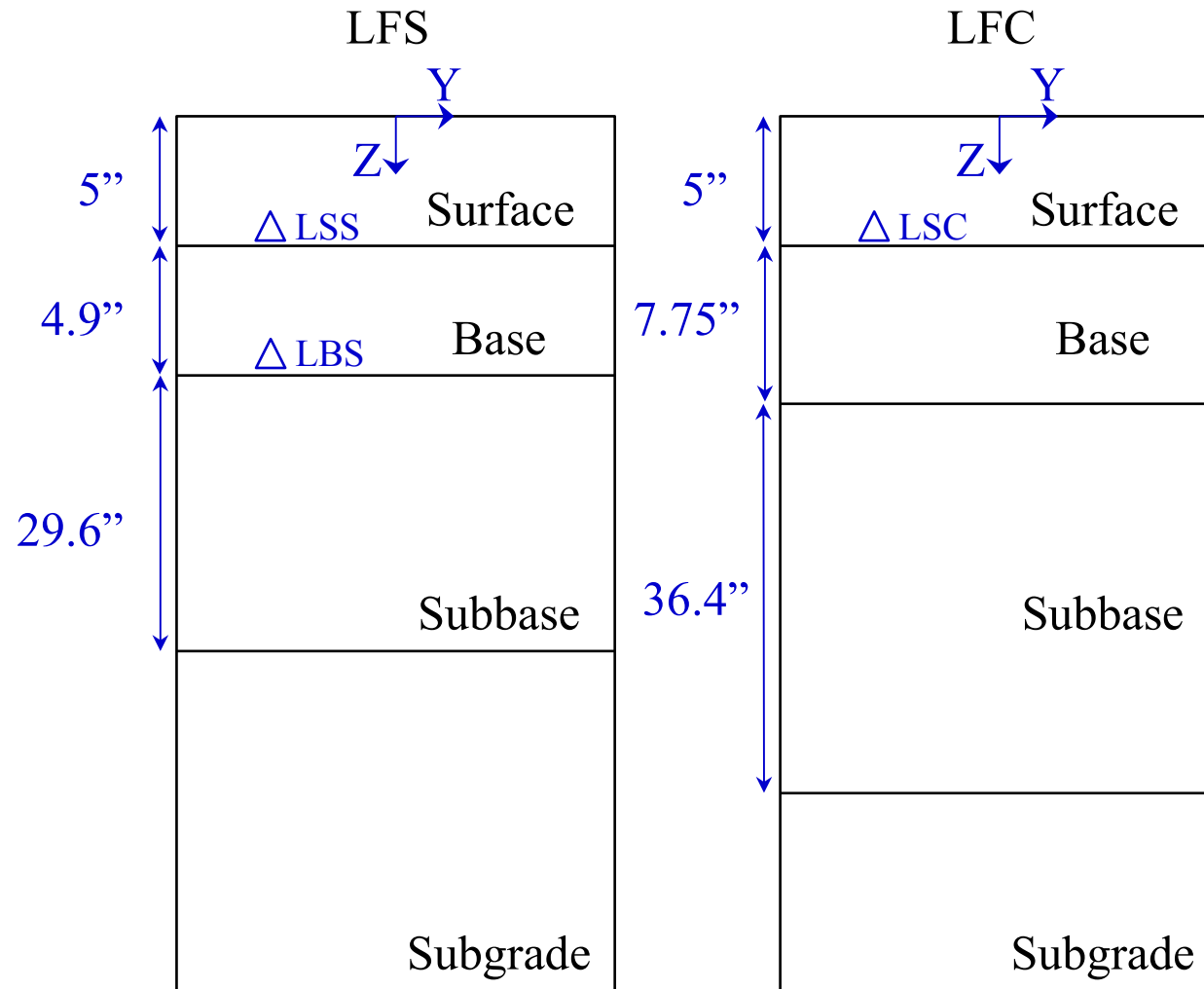
Only flexible pavements were considered for this study



# Typical Sensor Layout (Top View)

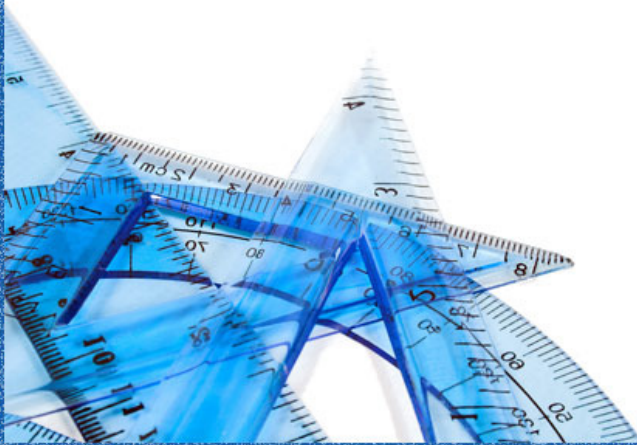


# Typical Sensor Layout (Side View)

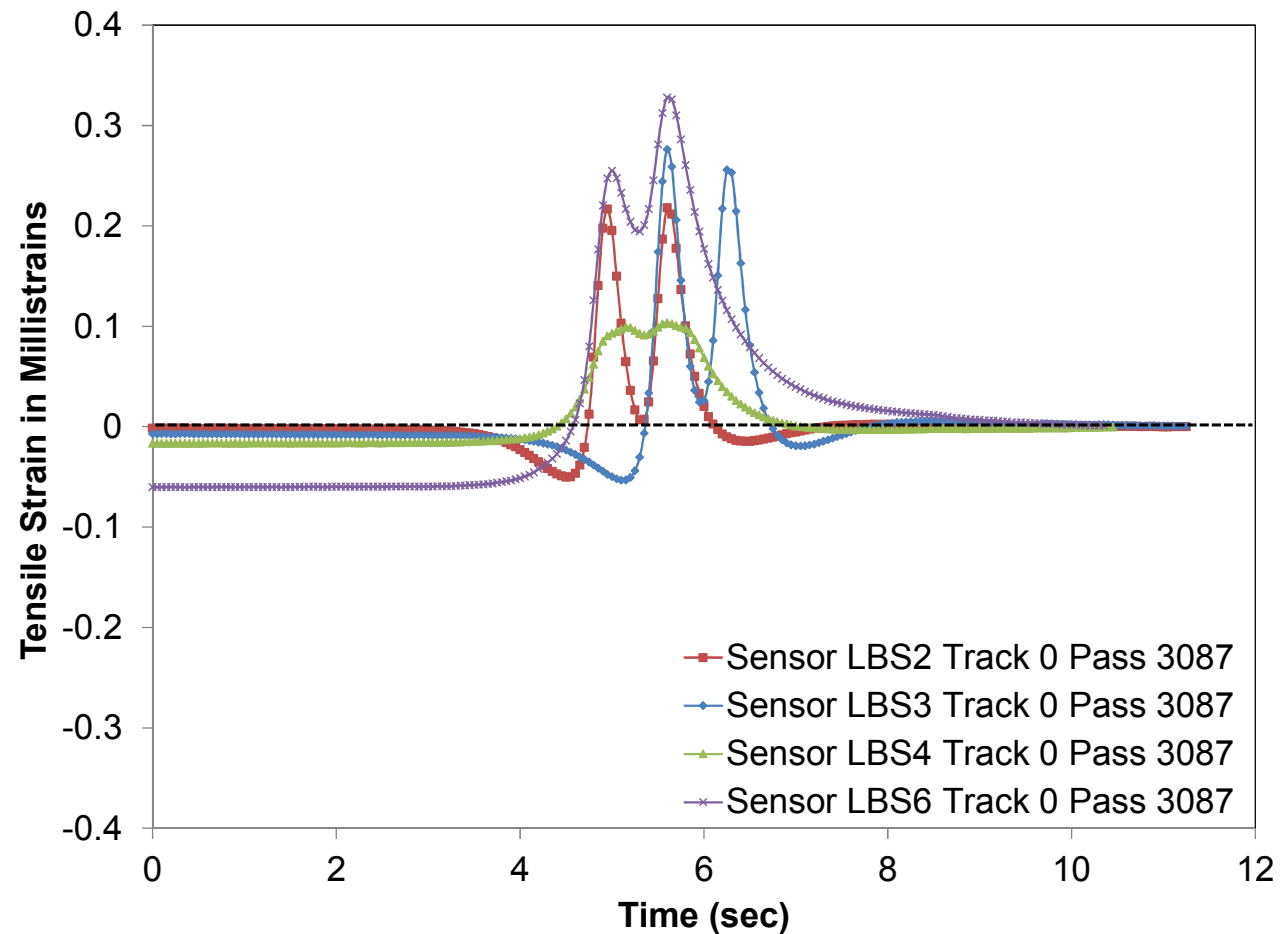
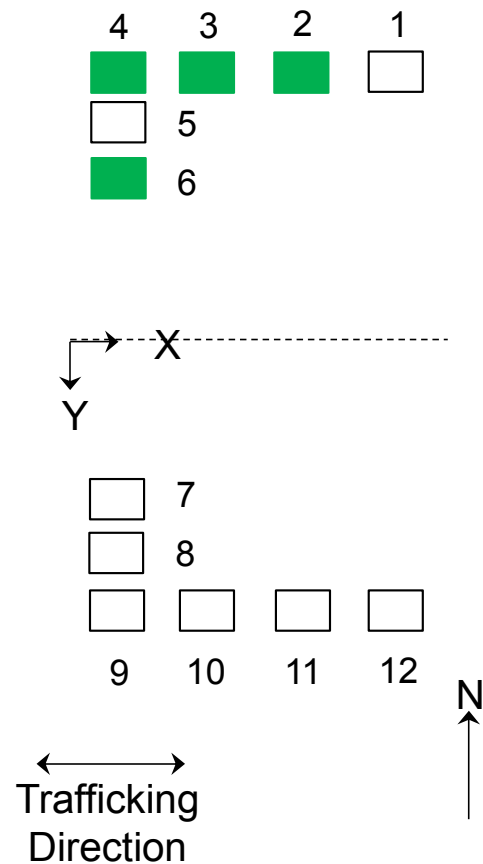




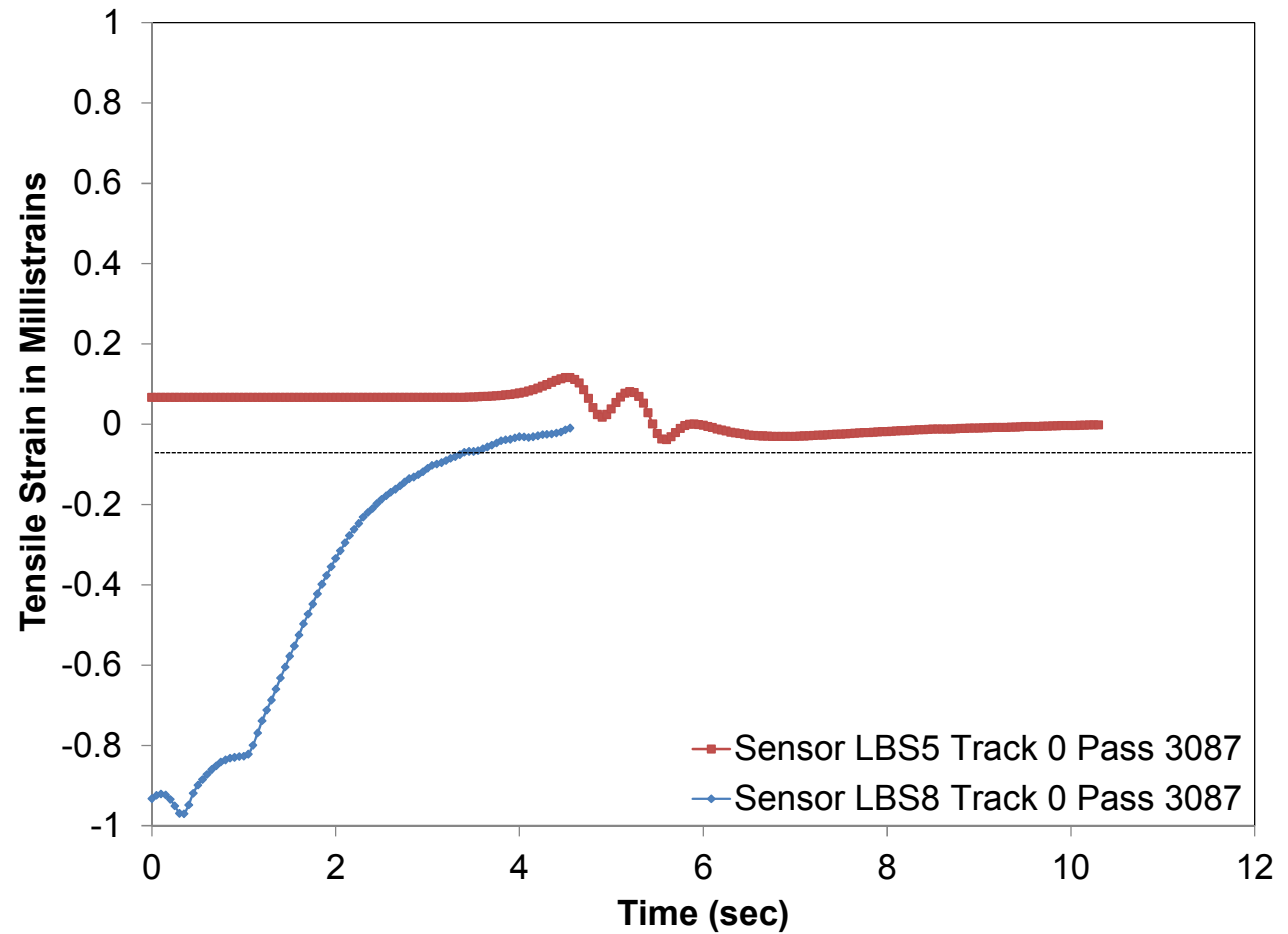
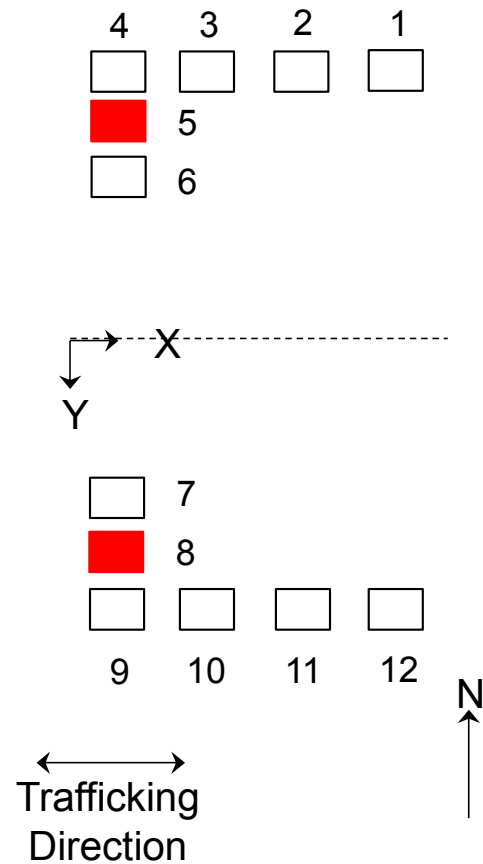
# Results & Findings



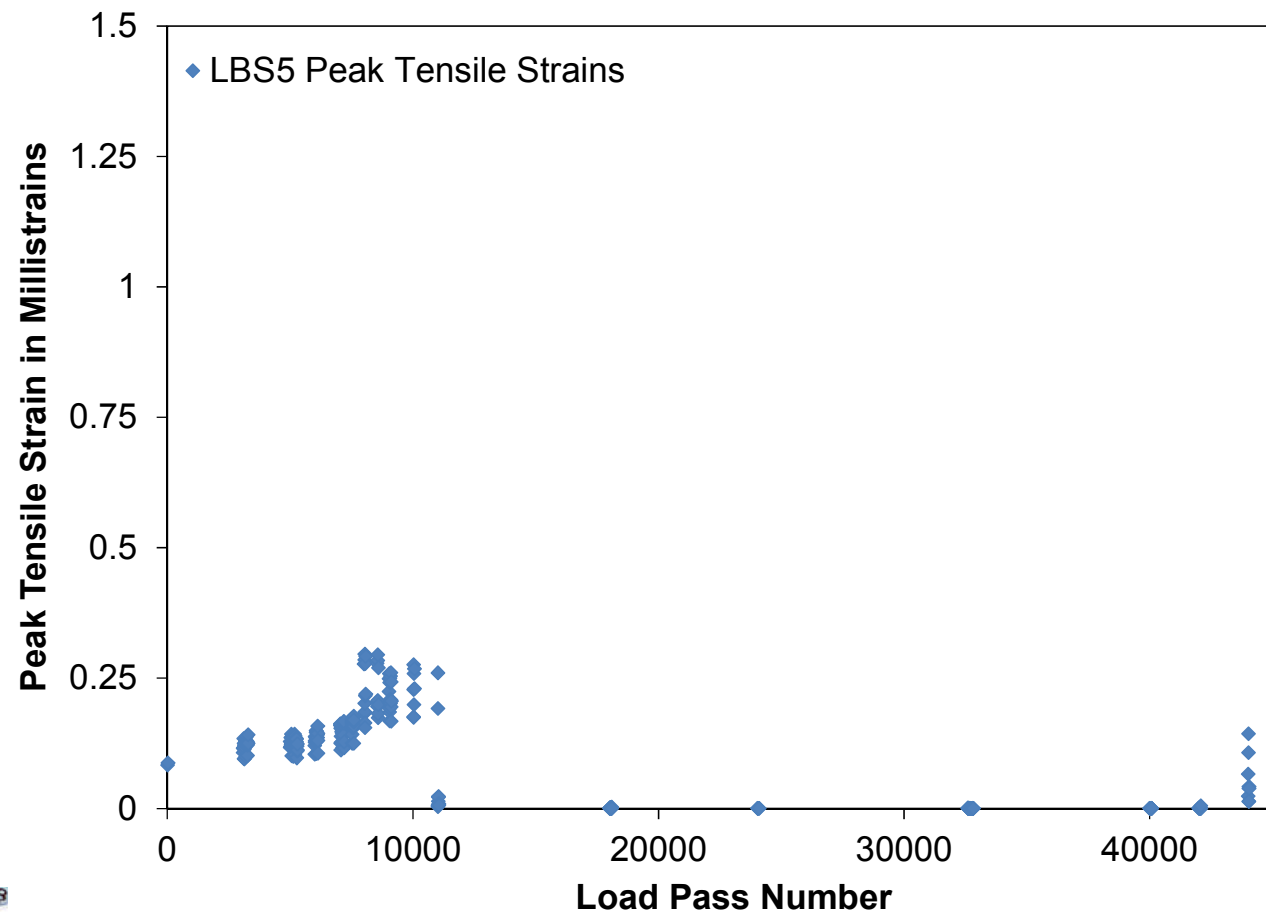
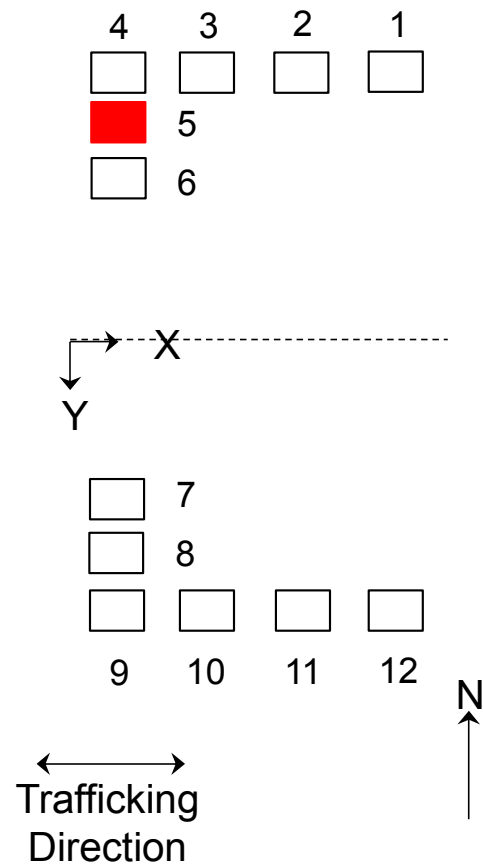
# Data Filtering (Good Data)



# Data Filtering (Bad Data)



# Data Filtering (Bad Data)





# Filtered Data

## Data Availability for Sensors Installed in Low-Strength Subgrade Sections

Sensor	Data Availability and Type	Sensor	Data Availability and Type	Sensor	Data Availability and Type
LBS1	xx	LSS1	xx	LSC1	✓x
LBS2	✓✓	LSS2	xx	LSC2	✓x
LBS3	✓✓	LSS3	✓x	LSC3	✓✓
LBS4	✓x	LSS4	xx	LSC4	xx
LBS5	✓x	LSS5	xx	LSC5	✓x
LBS6	✓✓	LSS6	xx	LSC6	✓x
LBS7	✓✓	LSS7	xx	LSC7	xx
LBS8	✓x	LSS8	xx	LSC8	✓x
LBS9	✓✓	LSS9	✓✓	LSC9	xx
LBS10	✓✓	LSS10	xx	LSC10	xx
LBS11	xx	LSS11	✓✓	LSC11	✓✓
LBS12	✓✓	LSS12	xx	LSC12	✓✓

✓✓: Data Available and Good; ✓✓: Not All Data available; ✓x: Data Available but Bad; and xx: No Data Available. 21

# Filtered Data

Data Availability for Sensors Installed in Medium-Strength Subgrade Sections

Sensor	Data Availability and Type	Sensor	Data Availability and Type	Sensor	Data Availability and Type
MBS1	✓✓	MSS1	xx	MSC1	xx
MBS2	✓✓	MSS2	xx	MSC2	✓✓
MBS3	✓✓	MSS3	xx	MSC3	✓✓
MBS4	✓✓	MSS4	xx	MSC4	✓x
MBS5	✓x	MSS5	xx	MSC5	✓x
MBS6	✓✓	MSS6	✓✓	MSC6	✓x
MBS7	✓✓	MSS7	✓✓	MSC7	✓✓
MBS8	✓✓	MSS8	✓✓	MSC8	✓x
MBS9	✓x	MSS9	xx	MSC9	✓x
MBS10	✓✓	MSS10	xx	MSC10	✓✓
MBS11	✓x	MSS11	xx	MSC11	✓✓
MBS12	✓✓	MSS12	xx	MSC12	✓✓

✓✓: Data Available and Good; ✓✓: Not All Data available; ✓x: Data Available but Bad; and xx: No Data Available.

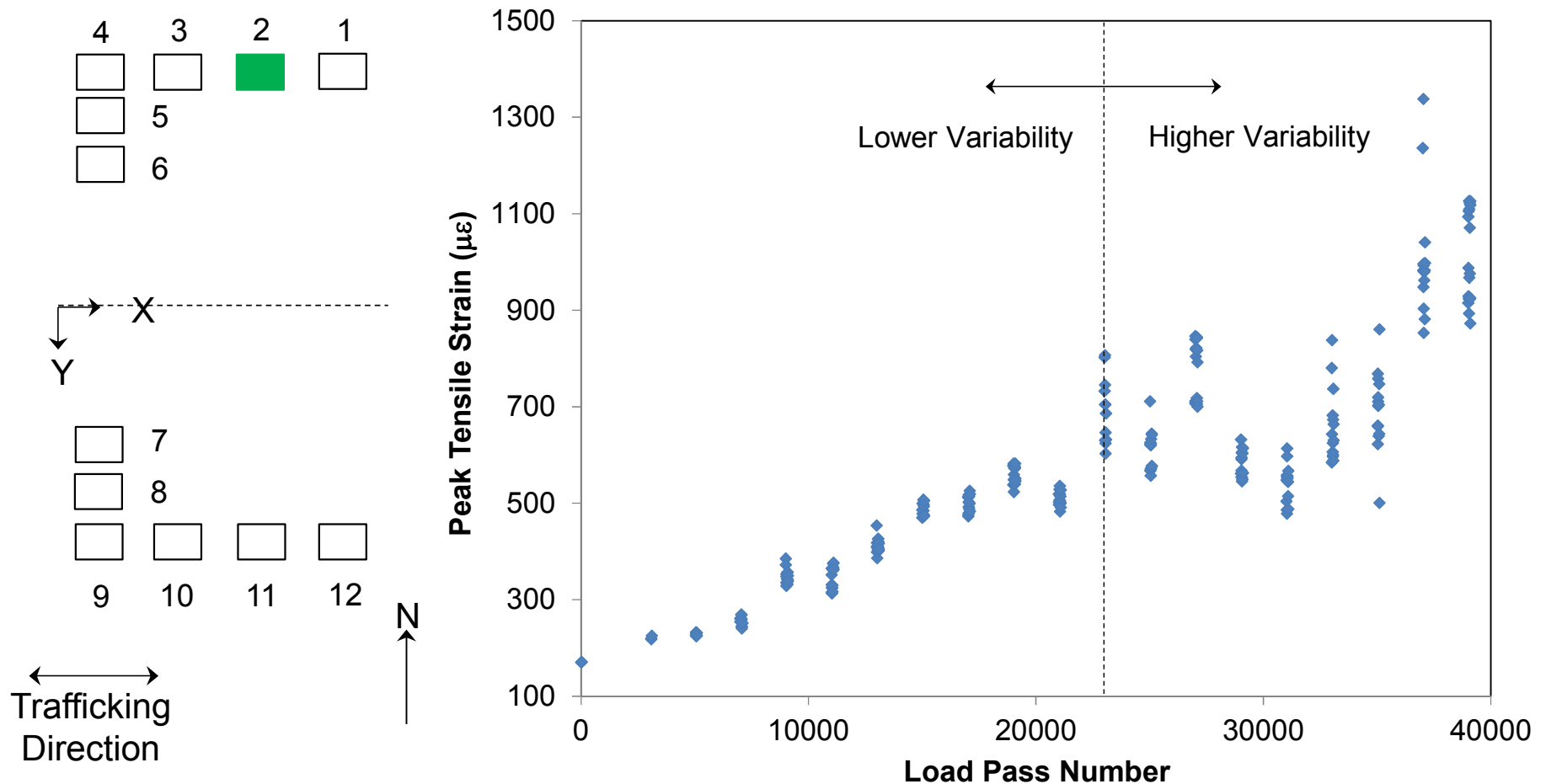
# Filtered Data

## Data Availability for Sensors Installed in High-Strength Subgrade Sections

Sensor	Data Availability and Type	Sensor	Data Availability and Type	Sensor	Data Availability and Type
HBS1	✓✓	HSS1	xx	HSC1	xx
HBS2	✓✓	HSS2	xx	HSC2	xx
HBS3	✓✓	HSS3	xx	HSC3	xx
HBS4	✓✓	HSS4	xx	HSC4	xx
HBS5	✓x	HSS5	xx	HSC5	xx
HBS6	✓✓	HSS6	xx	HSC6	xx
HBS7	✓✓	HSS7	xx	HSC7	✓✓
HBS8	✓x	HSS8	✓✓	HSC8	✓x
HBS9	✓x	HSS9	✓✓	HSC9	✓x
HBS10	✓✓	HSS10	✓✓	HSC10	✓✓
HBS11	✓✓	HSS11	✓✓	HSC11	✓x
HBS12	✓x	HSS12	✓x	HSC12	xx

✓✓: Data Available and Good; ✓✓: Not All Data available; ✓x: Data Available but Bad; and xx: No Data Available. 23

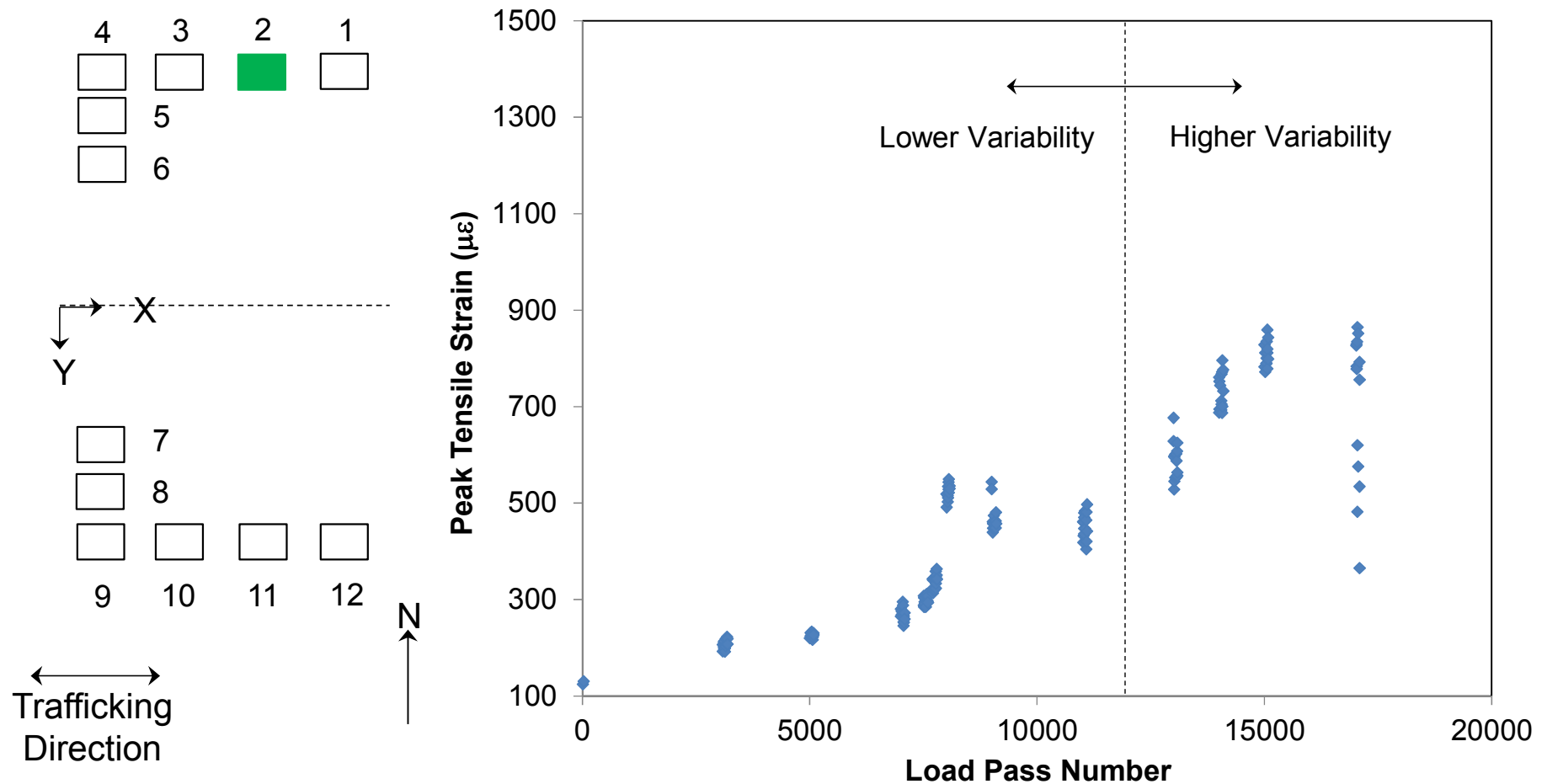
# Fatigue Endurance Limit Estimation



Strain Sensor LBS2



# Fatigue Endurance Limit Estimation



**Strain Sensor MBS2**

# Summary of Results

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LFS & LFC Sections	MFS & MFC Sections	HFS & HFC Sections
<ul style="list-style-type: none"><li>▪ Variability increase @ 20,000 load passes.</li><li>▪ FEL <math>\approx</math> 400 to 600 <math>\mu\epsilon</math></li></ul>	<ul style="list-style-type: none"><li>▪ Variability increase @ 12,000 load passes.</li><li>▪ FEL <math>\approx</math> 400 to 600 <math>\mu\epsilon</math></li></ul>	<ul style="list-style-type: none"><li>▪ No variability increase.</li><li>▪ Only 3000 load passes.</li></ul>



# Study Limitations



# Study Limitations

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- ☐ Only tensile strain data was used in this presentation to estimate a strain-based fatigue endurance limit.
- ☐ Variability in the peak tensile strain data might not be mainly due to fatigue cracking.
- ☐ More testing might be needed to further substantiate the approach.







Questions?

